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अनुभाग 1 विद्युत नोदन संयंत्र

Indian Standard

ELECTRICAL INSTALLATIONS IN SHIPS — SPECIFICATION

PART 5 SPECIAL FEATURES

Section 1 Electric Propulsion Plant

UDC 629·12·066 : 621·316·174 : 629·12·02/·07

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BUREAU OF INDIAN STANDARDS
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Electrical Equipment and Installations in Ships and Offshore Structures Sectional Committee, ET 26

FOREWORD

This Indian Standard (Part 5/Sec 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Electrical Equipment and Installations in Ships and Offshore Structures Sectional Committee had been approved by the Electrotechnical Division Council.

This standard (Part 5/Sec 1) is one among the series of the Indian Standards on electrical installations in ships. This series will have the following parts:

Part 1 General,
Part 2 System Design,
Part 3 Equipment,
Part 4 Installation and Test of Completed Installations, and
Part 5 Special Features.

In preparing this standard, assistance has been taken from the IEC Publication 92-501 (1984) 'Electrical installations in ships : Part 501 Special features — Electric propulsion plant', issued by the International Electrotechnical Commission.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ELECTRICAL INSTALLATIONS IN SHIPS — SPECIFICATION

PART 5 SPECIAL FEATURES

Section 1 Electric Propulsion Plant

1 SCOPE

This standard (Part 5/Sec 1) is applicable to electric propulsion machinery and plant and deals with the specifications, installation and testing of:

- propulsion motors;
- propulsion generators and their prime movers;
- electrical couplings;
- associated semiconductor convertors;
- excitation systems;
- control monitoring, instrumentation and protection equipment and systems; and
- wires and cables.

Bow and stern thrusters intended as auxiliary steering devices, all auxiliary generating plants and accumulator battery powered propulsion machinery and equipment are excluded.

NOTE — The requirements given in other clauses of relevant parts of IS 10242 'Electrical Installations in Ships' are also applicable to electric propulsion installations, unless otherwise mentioned in this standard. Requirements applicable to propulsion systems may also be applicable to other power consumers directly connected to the main electric propulsion system, the functioning of which may influence the propulsion or manoeuvrability of the ship.

2 REFERENCES

2.1 The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 DEFINITIONS

3.0 For the purpose of this standard, the following definitions shall apply.

3.1 Propulsion Machine (Electric)

A rotating machine normally intended to provide propulsive power.

3.2 Semiconductor Convertor

A static device using semiconducting elements to convert electric energy from one state to another.

3.3 Electrical Coupling

A coupling in which the torque is transmitted by the interaction of the magnetic field produced by magnetic poles on one rotating member and induced currents in the other rotating number.

The magnetic field may be produced by direct current excitation, permanent magnet excitation or alternating current excitation. The induced currents may be carried in a cage or insulated winding or may be present as eddy-currents.

NOTE — Couplings utilizing a wound secondary winding or a cage winding are known as slip or magnetic couplings. Couplings utilizing eddy-current effects are known as eddy-current couplings.

SECTION 1A GENERAL CONSIDERATIONS

4 TORQUE AND CRITICAL SPEEDS

4.1 The normal torque available in the propulsion motors for manoeuvring shall be such as to enable the vessel to be stopped or reversed when the vessel is travelling at its maximum service speed in a time to be agreed between the shipbuilder and the manufacturers of the electrical propulsion equipment based on the estimated torque-speed characteristics of the propeller during manoeuvring and on other necessary ship characteristics supplied to the manufacturers of the electrical systems.

NOTE — The requirements contained in this clause have to be agreed between the manufacturer and the purchaser.

4.2 Adequate torque margin shall be provided in a, c, propulsion systems to guard against the motor pulling out of synchronism during rough weather and on a multiple screw vessel when turning, based on the information provided regarding propeller and ship characteristics.

4.3 In order to prevent excessive torsional stresses and torsional vibrations of excessive magnitude, careful consideration shall be given to co-ordination of the mass constants and the elasticity constants of the entire propulsion system, and electrical characteristics in the system.

4.4 The entire system may include prime movers, generators, convertors, exciters, motors, slip-couplings, gearing, shafting and propellers.

The manufacturers of the components shall provide all necessary information to the parties responsible.

5 LUBRICATION

5.1 The lubrication of the bearings of propulsion motors, gearing and shafting shall be effective at all normal speed from creep speeds upwards either ahead or astern.

5.2 The shafts and bearings shall not be damaged by slow rotation, whether or not electrical power is applied to the motor or whether such rotation is induced by the propellers, and under predictable oil temperature conditions.

6 GENERAL REQUIREMENTS OF PRIME-MOVERS

6.1 Prime-movers of any type shall be provided with a governor capable of maintaining the preset steady speed within a range not exceeding 5 percent of the rated full-load speed for load changes from full-load to no-load.

Where the speed control of the propeller requires speed variation of the prime-mover, the governor shall be provided with means for local manual control as well as for remote control.

In case of parallel operation of generators, the governing system used shall permit stable operation to be maintained over the entire operational speed range of the prime-movers.

6.2 The prime-mover rated power in conjunction with its overloading and load build-up capabilities shall be adequate to supply the power needed during transitional changes in operating conditions of the electrical equipment due to manoeuvring and sea and weather conditions.

NOTE — With respect to the above, special attention should be paid to diesel engines equipped with exhaust gas-driven turbine blowers for supercharging.

6.3 When manoeuvring from full propeller speed ahead to full propeller speed astern with the ship making full way ahead, the prime-mover shall be capable of absorbing a proportion of the regenerated power without tripping due to overspeed.

The setting of the overspeed trip device shall be in accordance with the requirements of the appropriate authority and the amount of the regenerated power to be absorbed agreed to by the electrical and mechanical machinery manufacturers.

Means external to the mechanical and electrical rotating machinery may be provided in the form of phantom or dynamic braking resistors, or ballast consumers to absorb excess amounts of regenerated energy and to retard the speed of rotation of the propulsion motor.

Alternatively, the amount of regenerated power may be limited by the action of the control system.

NOTE — The requirements contained in this clause have to be agreed upon between the manufacturer and the purchaser.

SECTION 1B GENERATORS, MOTORS, SEMICONDUCTOR CONVERTORS AND ELECTRIC SLIP-COUPLINGS

7 MACHINE AND EQUIPMENT TEMPERATURE AND VENTILATION

7.1 When generators, motors or slip-couplings are fitted with an integral fan (*see* IS 6362 : 1971) and shall be operated at speeds below the rated speed with full-load torque, full-load current, full-load excitation or the like; temperature limits according to Table 1 of IS 10242 (Part 3/Sec 1) : 1983 shall not be exceeded.

7.2 The temperature of the cooling air of machines provided with forced air ventilation, air ducts or air filters shall be continuously monitored by means of direct reading thermometers which are readable from outside the machine and a remote audible alarm actuated by suitable temperature detectors.

For machines with a closed circuit cooling method with a heat exchanger, the flow of primary and secondary coolants shall be monitored.

Alternatively, monitoring of winding temperature plus alarm may be accepted in lieu of flow alarm although both the alarms would be preferable.

Consideration shall be given to the necessity for providing equipment for detecting leakage of cooling liquid in a machine enclosure and operating an associated alarm.

7.3 If semiconductor convertors are fitted with forced-ventilation, monitoring means for the cooling system shall be provided.

In case of a failure of the cooling system, an alarm shall be given or the current shall be reduced automatically. The alarm signed can be generated by the flow of the coolant, by the electric supply to the ventilator or by the temperature of diodes and thyristors.

7.4 Stator windings of ac machines and interpole windings of dc machines, all rated above 500 kW, shall be provided with temperature sensors.

8 ACCESSIBILITY AND FACILITIES FOR REPAIRS *IN SITU*

8.1 For purposes of inspection and repair, provision shall be made for access to the stator and rotor coils, and for the withdrawal and replacement of field coils.

8.2 Facilities shall be provided for supporting the shaft inspection and withdrawal of bearings.

8.3 Adequate access shall be provided to permit resurfacing of commutators and slip-rings, as well as renewal and bedding of brushes.

8.4 Slip-couplings shall be designed to permit removal as a unit without axial displacement of the driving and driven shaft, and without removing the poles.

9 PROTECTION AGAINST MOISTURE AND CONDENSATE

9.1 Effective means shall be provided in propulsion machines and convertors to prevent accumulation of moisture and condensate, even if they are idle for appreciable periods (for example by means of spare heaters).

10 SUDDEN SHORT CIRCUITS

10.1 AC machines shall be capable of withstanding a sudden short circuit at their terminals under rated conditions without suffering damage.

11 OVERSPEEDING OF DC PROPULSION MOTORS

11.1 The rotors of dc propulsion motors shall be capable of withstanding overspeeding up to the limit reached in accordance with the characteristics of the overspeed protection device at its normal operational setting.

12 EXCITER SETS

12.1 The obtainable current and voltage of exciters and their supply shall be suitable for the output required during manoeuvring and overcurrent conditions including short-circuit.

12.2 For this reason, attention shall be paid to the strength of shafts and couplings of rotating sets and to the power of their driving machines.

13 SEMICONDUCTOR CONVERTOR DESIGN DATA

13.1 The following limiting repetitive peak voltages shall be used as a base for the semiconductor valve:

- when connected to a supply specifically for propeller drives

  $U_{RM} = 1{\cdot}5\ U_P$;

- when connected to a common main supply

  $U_{RM} = 1{\cdot}8\ U_P$

(U_P is the peak value of the rated voltage at the input of the semiconductor convertor).

If the semiconductors are connected in series, the values mentioned above shall be increased by 10 percent equal voltage distribution shall be ensured.

13.2 Semiconductor convertor circuits shall be able to withstand the transient overcurrents to which the system is subject during manoeuvring as referred to in **4.1**.

The following measures shall also be taken:

- for parallel-connected convertor valves an equal current distribution shall be ensured;
- where convertors are force-ventilated it is essential that on fan failure they can be operated at reduced power.

If several elements are connected in parallel and a separate fan is fitted for each parallel branch, it suffices to disconnect only those branches for which ventilation is not available.

13.3 When semiconductor convertors are used, means shall be taken, where necessary, to limit the effect of disturbances, both the system and to other semiconductor convertors. Attention shall be paid to:

- convertors when connected to the same busbar system;
- commutation reactance which, if insufficient, may result in voltage distortion adversely affecting other consumers on the system;
- the relation between the system subtransient reactance and the convertor commutation reactance. Unsuitable matching may result in the production of voltage harmonics which could cause overheating of other consumers;
- any adverse effect of convertors on the commutation of dc machines;
- any adverse effect, in the regenerating mode, if voltage drops on inverter operation;
- interference from high frequency noise.

When filter circuit and capacitors are used for reactive current compensation, attention shall be paid to:

- any adverse effect of frequency variations on the rms and peak values of system voltage;
- any adverse effect on voltage regulation of generators.

13.4 The following protection of convertors shall be provided:

- overvoltages in a supply system to which convertors are connected shall be limited by suitable devices to prevent damage. Protective fuses for these devices shall be monitored;
- a suitable control shall ensure that the permissible current of semiconductor elements cannot be exceeded during normal operation;

- short-circuit currents shall be limited by specially adapted fuses. These semiconductor protective fuses shall be monitored. In case of fuse operation, the respective part of the plant shall be taken out of operation;
- fuses in filter circuits shall be monitored.

NOTE — Consideration should be given to include excessive current ripple in the scheme of protection.

SECTION 1C CONTROLGEAR

14 LOCATION OF MANOEUVRING CONTROLS

14.1 The main propulsion manoeuvring controls may be located at any convenient place.

Whenever control outside the engine room is applied, an arrangement shall be provided whereby the propulsion plant can also be controlled from the engine room, or control room.

15 OPERATION OF MANOEUVRING CONTROLS

15.1 Either manual operation or operation with the aid of power or a combination of both may be used.

In case of manual operation, all manoeuvring switches, field-regulators and controllers shall be operable without undue effect.

If failure of the power supply occurs in systems with power-aided control (for example with electric, pneumatic or hydraulic aid), it shall be possible to restore control in a short time.

When two or more control stations are provided outside the engine room a selector switch or other means shall be provided for transferring the manoeuvring controls to the designated station. Indication of which control station is in command shall be provided at the selector switch and at each control station. Simultaneous control from more than one control station shall not be possible.

Changing of the control station shall be possible only when the control levers of the station in command and the incoming station are in the same position or when an acceptance signal set by the desired station is received. This is not required for systems in which the control levers are electrically or mechanically interconnected in such a manner that each lever will be set to the same position.

The control equipment shall be so arranged that in case of damage to the equipment outside the engine room, control can always be executed from the engine room or the engine control room manoeuvring control stations.

It is recommended that failure of power aid, when used, shall if possible not result in an interruption of the power to the propulsion shaft, but be indicated by an alarm.

16 INTERLOCKING OF THE MEANS OF CONTROL

All control means for operating prime-movers, set-up switches, contactors, field switches, etc, shall be interlocked to prevent their incorrect operation.

SECTION 1D CABLES AND WIRING

17 CONSTRUCTION

17.1 The conductors of cables external to the components of the propulsion plant, other than cables and interconnecting wiring for computers, data loggers or other automation equipment requiring currents of very small value, shall consist of not less than seven strands and have a cross-sectional area of not less than 1·5 mm^2.

The mechanical strength and insulation qualities of all cables shall be adequate for the duty intended and shall in no way endanger the safety of the ship.

17.2 The insulation of internal wiring in main controlgear, including switchboard wiring, shall be of flame-retardant quality.

SECTION 1E MAIN AND CONTROL CIRCUITS

18 CIRCUITRY AND COMPONENTS

18.1 Systems having two or more propulsion generators, two or more semiconductor convertors or two or more motors on one propeller shaft shall be so arranged that any unit may be taken out of service and disconnected electrically.

18.2 If a propulsion system contains only one generator and one motor and cannot be connected to another propulsion system, more than one exciter set shall be provided for each machine. However, this is not necessary for self-excited generators or for multi-propeller propulsion ships where any additional exciter set may be common for the ship.

18.3 Every exciter set shall be supplied by a separate feeder.

18.4 Field circuits shall be provided with means for suppressing voltage rise when a field switch is operated.

18.5 For Ward-Leonard systems, arrangements for generator and motor excitation shall be such that if the motor excitation circuit is operated by a switch or contactor, the generator excitation circuit is simultaneously opened or the generator voltage is immediately reduced to zero.

In constant voltage systems with two or more independently controlled motors in parallel on the same generator(s), the armature circuit-breaker shall be tripped when an excitation circuit is operated by a switch or contactor.

When using semiconductor exciter sets and when the diodes or thyristors are necessary to protect the field coils against transient overvoltages or when they are used as free-wheeling diodes, the arrangement of the semiconductor fuses shall prevent opening of the excitation circuit.

Where fuses are used for excitation circuit protection it is essential that they do not interrupt the field discharge resistor circuit upon rupturing.

18.6 If a ship service generator is also used for propulsion purposes, other than for boosting the propulsion power, the components then being part of the propulsion circuit shall be in accordance with the requirements of this standard.

18.7 In regulating systems with feedback control special consideration shall be given to ensure a high degree of reliability.

18.8 Failure of a control signal shall not cause an excessive increase in propeller speed.

The reference value transmitters in the control stations and the control equipment shall be so designed that any defect in the desired value transmitters or in the cables between the control station and the propulsion system will not cause a substantial increase in the propeller speed.

18.9 The control of the propulsion system can be activated only when the delegated control lever is in zero position and the system is ready for operation.

18.10 Each control station shall have an emergency stop device which is independent of the control lever.

SECTION 1F PROTECTION OF THE SYSTEM

19 PROTECTION

19.1 Over-current protective devices, if any, in the main circuits shall be set sufficiently high so that there is no possibility of their operating due to the overcurrents caused by manoeuvring or normal operation in heavy seas or in floating broken ice.

19.2 For dc systems in which excessive overspeeding of the propulsion motors may occur for example, at light loads or loss of a propeller, suitable overspeed protection shall be provided.

19.3 Where separately driven dc generators are connected electrically in series, means shall be provided to prevent reversal of the rotation of a generator upon failure of the driving power of its prime-mover.

19.4 In excitation circuits, there shall be no overload protection causing the opening of the circuit.

19.5 Means shall be provided for selective tripping or rapid reduction of the magnetic fluxes of the generators and motors to ensure that overcurrents do not reach values which may endanger the plant.

19.6 Means for earth leakage detection shall be provided for the main propulsion circuit, and be arranged to operate an alarm upon the occurrence of an earth fault. When the fault current flowing is liable to cause damage, tripping arrangements shall also be provided.

19.7 Means shall be provided for earth leakage detection in excitation circuits of propulsion machines but may be omitted in circuits of brushless excitation systems and of machines rated up to 500 kW.

19.8 Consideration shall be given in the design of machines and their protective systems to the measures necessary to minimize damage in the event of short circuit.

19.9 Semiconductor elements in semiconductor convertors shall have fuse protection.

19.10 If there is a possibility of blocking the propeller (during ice-breaking conditions) a protection against damage of the propulsion plant shall be provided.

20 INSTRUMENTATION

20.1 At least the following instruments, in addition to those required in IS 10242 (Part 3/Sec 2) : 1984, shall be provided and mounted in the main control assembly or any other suitable location.

NOTE — Attention should be paid to the effect of regenerated power on wattmeters and ammeters as the values may exceed these assumed in IS 10242 (Part 3/Sec 2) : 1984.

20.2 AC Propulsion Systems

For each propulsion generator:

- — an ammeter;
- — a voltmeter;
- — a wattmeter; and
- — a tachometer or frequency meter.

NOTE — When the rated power of semiconductors is a substantial part of the rated power of the generators, the voltmeters of the generator(s) should display the arithmetical mean value of the voltage.

Alternatively of multigenerator systems, switched voltmeters and frequency meters may be used.

A power factor meter or a kilovarmeter or a field ammeter will also be required if generators are to be operated in parallel.

For propulsion generators rated above 500 kW:

- a temperature indicator for reading directly the temperature of the stator windings.

For propulsion motors fed from the main electrical system:

- an ammeter for the main current of each motor, and
- an ammeter for the field current of each synchronous motor.

For propulsion motors rated above 500 kW:

- a temperature indicator for reading directly the temperature of the motor windings.

For each propeller shaft:

- a speed indicator.

For semiconductor convertors:

- an ammeter for each bridge connection of semiconductors.

20.3 DC Propulsion Systems

For each propulsion generator:

- an ammeter,
- a voltmeter, and
- a field ammeter.

For each propulsion motor:

- a field ammeter.

For propulsion motors fed from the main electrical system:

- an ammeter for the armature current of each motor.

For propulsion motors fed by semiconductor convertors:

- an ammeter for the armature current of each motor,
- a voltmeter for the armature voltage of each motor, and
- an ammeter in the input of each parallel bridge circuitry of the convertor.

For propulsion motors rated above 500 kW:

- a warning for excessive temperature of the interpole windings.

For each propeller shaft:

- a speed indicator.

20.4 When two or more control stations are provided for variable speed propellers, a propeller speed indicator shall be provided at each control station.

20.5 Where control outside the engine room is used, instruments giving the necessary information on the main electric propulsion system shall be installed at a convenient location near such a station.

20.6 The control stations of the propulsion systems shall have at least the following indications for each propeller:

“ready for operation” — power circuits and necessary auxiliaries are in operation

“faulty” — propeller is not controllable

“power limitation” — in case of disturbance for example, in the ventilators for propulsion motors, in the convertors, cooling water supply or load limitation of the generators.

SECTION 1G TESTING

In addition to the standard tests prescribed in other clauses of IEC Publication 92, the following special tests shall be carried out.

21 WORK TESTS

21.1 As far as practicable, all normal acceptance tests of individual items of equipment shall be carried out at the manufacturer’s works to show that they meet the requirements of this standard.

In addition to the standard tests prescribed in other clauses of relevant parts of IS 10242 all protective devices shall be tested to show that they are electrically and mechanically satisfactory.

21.2 Dock and Sea Trials

21.2.1 Complete tests shall be carried out including duration runs and manoeuvring tests which should include a reversal of the ship from full speed ahead to full speed astern, tests for operation of all protective devices and stability tests for control.

All tests necessary to demonstrate that each item of plant and the system as a whole are satisfactory for duty shall be performed.

Immediately prior to trials the insulation resistance shall be measured and recorded.

ANNEX A

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
6362 : 1971	Designation of methods of cooling of rotating electrical machines
10242 (Part 3/Sec 1) : 1983	Electrical installations in ships: Part 3 Equipment, Section 1 Generators and motors
10242 (Part 3/Sec 2) : 1984	Electrical installations in ships: Part 3 Equipment, Section 2 Switchgear and controlgear assemblies

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